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Preliminary Analysis of University of North Dakota Aircraft Data
from the FIRE Cirrus IFO-II

Semi-annual Status Report

for the period

October 15, 1992 to April 14, 1993

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1.0 Introduction

This report describes the progress and performance by the University of North Dakota under NASA Research Award NAG-1-1351 - "Preliminary Analysis of University of North Dakota Aircraft Data from the FIRE Cirrus IFO-II," for the period October 15, 1992 to April 14, 1993. Included is a summary of the data archival status and preliminary analysis efforts.

2.0 Data Archival

During this reporting period, data archival efforts were directed toward providing reduced data for the FIRE data archive and fulfilling special requests for reduced and value-added data.

2.1 FIRE Data Archive

Three sets of data collected by the UND Citation II research aircraft during the second cirrus IFO have been submitted for inclusion in the FIRE Data Archive. One consists of all meteorological and flight data excluding the data generated by the Particle Measuring Systems (PMS) probes and the Desert Research Institute (DRI) particle replicator. The PMS data files are described below; the DRI replicator films are archived at DRI. The flight data have been submitted in ASCII format. A description of the file layout, a list of parameters, and some brief comments on data quality are attached to this report ("ASCII Flight Data Files").

The other two data sets include the PMS 1D-P, 1D-C, 2D-C, and FSSP probe data. These are the raw data (channel counts, image slices, probe activity, etc.) generated by these probes; these are not particle concentrations, size distributions and the like. The 1D-P, 1D-C, and FSSP data are combined into one file. These probes were sampled at a rate of 4 Hz. The 2D-C probe image slice data are contained in a separate file. These images were generated only when the probe detected the presence of particles and were recorded at a rate of up to 4 Hz. A description of the layout of these two file types and notes regarding their use are attached to this report as "PMS One-D" and "PMS Two-D" record descriptions.

2.2 Special Data Requests

A number of requests for UND Citation data were received from FIRE investigators and were filled. A few of these requests were for reduced data before it had been formally archived. Most were for value-added products, especially cloud microphysical parameters derived from PMS data, for specific missions or flight

times. A total of seven individual requests were satisfied during this reporting period.

3.0 Analysis

Analysis efforts focused on three separate studies. Work continued on a collaborative investigation of the possible effects of volcanic aerosols on cirrus morphology. This is a case study of remote and in situ measurements made during the nighttime hours of 5 December 1991; the analysis is being led by Dr. Kenneth Sassen of the University of Utah. The Citation microphysical and aerosol data show a high likelihood that this cirrus system existed within an airmass recently affected by a stratospheric intrusion. Volcanic aerosols from the eruption of Mt. Pinatubo appear to have been brought down into the upper troposphere; coincidentally, the cirrus cloud particles were sampled in the highest concentrations of the project. The results of this study have been submitted for publication.

A second on-going study was a comparison of cloud microphysical characteristics as sampled by PMS probes and the DRI particle replicator. Preliminary findings confirm that there are significant numbers of ice particles in cirrus which are too small to be detected by the PMS optical array probes. The measurements show good overlap for concentrations and sizes of particles with diameters of 100-200 μm , and some oversizing by the replicator of the larger particles. These findings have implications for the modeling of the radiative effects of cirrus clouds and other uses of these microphysical data.

The third area of analysis is in support of the development by NASA investigators of a scheme for the retrieval of multiple cloud-top heights from satellite data. The Citation data are being used to determine actual cloud-top heights in a case where there were multiple cloud layers. These data are being compared with the output of the retrieval and with ground-based measurements made simultaneously in the same area.

4.0 Meetings Attended

The Principal Investigator traveled to Fairfax, VA, to attend the FIRE Science Team Meeting - Cirrus Working Group, November 11-15, 1993. Discussions were held regarding preliminary analysis findings and the status and organization of case study groups. A status report of the data processing and archival of the UND Citation data was presented.

University of North Dakota Citation II
 FIRE Cirrus IFO - II
 ASCII Flight Data Files
 (all data excluding microphysics)

Flight data collected by the University of North Dakota Citation II research aircraft during the FIRE Cirrus IFO-II are available in ASCII format at a 1 Hz rate. Cloud microphysics data from the PMS probes or the DRI replicator are not included in these files. The following is a description of the file layout and equipment concerns.

The ASCII file record length is 512-bytes. The first six records of each file contain file description and calibration information. Data records are written as 51F10.3 format and contain the time (UTC) followed by 50 parameters expressed in meteorological/engineering units, as follows:

<u>Parameter</u>	<u>Units</u>
Time	seconds after midnight
Pressure altitude	m
Static pressure	mb
Indicated airspeed	m s ⁻¹
True airspeed	m s ⁻¹
Ground speed	m s ⁻¹
Pitotstatic pressure, nose	mb
Pitotstatic pressure, wing	mb
Temperature, Rosemount	deg-C
Temperature, reverse flow	deg-C
Dew point temperature	deg-C
Ice detector	V
Ice detector liquid water	g m ⁻³
JW liquid water	g m ⁻³
VOR radial	deg
DME	km
Vertical acceleration	m s ⁻²
Attack delta pressure	mb
Sideslip delta pressure	mb
Attack angle	deg
Sideslip angle	deg
Ozone concentration	ppb
NO ₂ concentration	ppb
Condensation nuclei	cm ⁻³
DRI film speed	1-8 (5-40 frames s ⁻¹)
DRI frame count	frames
DRI event mark	V
Potential temperature	deg-K
Ice detector heater flag	V
Track angle	deg

Drift angle	deg
True heading	deg
Magnetic heading	deg
Pitch angle	deg
Roll angle	deg
INS wind direction	deg
INS wind speed	m s ⁻¹
Aircraft vertical velocity	m s ⁻¹
Vertical wind	m s ⁻¹
Calculated wind speed	m s ⁻¹
Calculated wind direction	deg
INS latitude	deg
INS longitude	deg
INS latitude, VOR/DME corrected	deg
INS longitude, VOR/DME corrected	deg
GPS time	hr
GPS latitude	deg
GPS longitude	deg
GPS altitude	m
GPS velocity north	m s ⁻¹
GPS velocity east	m s ⁻¹

GPS Data Quality

Due to DOD system test, GPS signal was not valid all flights

<u>Flight</u>	<u>Position</u>	<u>Altitude</u>
11/14	Good	Good
11/22 A	Last 40%	No
11/22 B	No	No
11/25	Good	Good
11/26	Good	Good
11/28	Good	Good
11/30	No	No
12/5 A	Last 40 min	No
12/5 B	Good	Good
12/7	Good	Good

Other equipment concerns:

CN - valid only from 11/26 to end of program
 O₃ - not calibrated
 - inoperative 11/28, 11/30
 NO₂ - inoperative 11/14, 11/28
 2D-C - inoperative last 35% of 11/26, all of 11/28

The PMS One-D record has 8 logical records per physical record. The physical record is 2048 bytes total. Hwrd is a 16 bit integer. Here is the format for each logical record of PMS data.

Revised:

Ver.	Date	Programmer
7.0	16 November 1989	Martin Brown

PMS calculations have been added to the record for inclusion in the Amiga data. The data are in Concurrent Computer floating point format. Bytes 208 through 239.

Byte	Hwrd	Value
00-03	1-2	Recorded Time (10000*SecondsFromMidnight)
04-05	3	TAS (100*TAS) in meters per second
06-07	4	Spare
08-11	5-6	Date (mmddyy)
12-13	7	2-DA Shadow Or Count
14-15	8	2-DA Housekeeping Channel
16-17	9	2-DA TAS Count
18-19	10	2-DA Housekeeping Channel Number
20-21	11	FSSP Size Range (See notes)
22-23	12	FSSP Channel One Count
:	:	:
:	:	:
50-51	26	FSSP Channel Fifteen Count
52-53	27	Spare FSSP counter
54-55	28	FSSP total (Ch 1-15)
56-57	29	FSSP total strobes
58-59	30	FSSP activity
60-63	31-32	Spare
64-65	33	Particle Spacing Monitor (PSM) Range/Control
66-67	34	PSM Channel One
:	:	:
:	:	:
94-95	48	PSM Channel Fifteen
96-97	49	1D-C Range/Control
98-99	50	1D-C Channel One Count
:	:	:
:	:	:
158-159	80	1D-C Channel Thirty-one Count
160-161	81	1D-C Total (Ch 1-31)
162-163	82	1D-C Spare Counter #1
164-165	83	1D-C Spare Counter #2
166-167	84	1D-C Spare Counter #3
168-175	85-88	Spare
176-177	89	1D-P Range/Control
178-179	90	1D-P Channel One Count
:	:	:
:	:	:
206-207	104	1D-P Channel Fifteen Count

The remaining values were generated for real-time display.

208-211	105-106	FSSP concentration, no./cc.
212-215	107-108	FSSP mean volume diameter, microns.
216-219	109-110	FSSP liquid water, gm/cu.meter.
220-223	111-112	1DC concentration, no./liter.
224-227	113-114	1DC mean volume diameter, microns.
228-231	115-116	1DP concentration, no./cu.meter.
232-235	117-118	1DP mean volume diameter, microns.
236-239	119-120	2DC concentration, no./liter. (shadow/or)

Notes:

For the FSSP, PSM, 1-DC and 1-DP size ranges, each is stored in a halfword with other information on a bit function. With bit 0 being the high order bit, the information is --

- bits 0-3 always 0
- bit 4 transit delay - should be 0
- bit 5 velocity averaging - should be 0
- bits 6-7 size range

Transit delay and velocity averaging are no longer available. These lines are being used for FSSP total strobes and FSSP activity.

The 1-DC probe and the 1-DP probe are not adjustable and have no size range. The size range values reflect the setting of the switches on the front pannel of the SEA Model 100.

The 1-DP size range halfword and the PSM size range halfword is being used by the display and may have any value.

The FSSP probe has four size ranges (0-3):

*** (for FIRE, only range 0 was used) ***

- 0 - 3.0 to 47.5 microns
- 1 - 2.0 to 32.0 microns
- 2 - 1.0 to 16.0 microns
- 3 - 0.5 to 8.0 microns

The FSSP size range is set using the switches on the front panel of the SEA Model 100.

The housekeeping channel number for the 2-D probes identifies a particular housekeeping channel. Only one of the eight housekeeping channels is recorded with each logical record for each probe (the same channel for both probes, however.)

- 0 - +15 V power supply
- 1 - mirror temperature
- 2 - spare
- 3 - spare
- 4 - end element #1
- 5 - end element #32
- 6 - -15 V power supply
- 7 - +5 V power supply

The -15 volt power supply value is recorded as positive. Each of the values has been changed from a voltage to a frequency. One volt is changed to one kilohertz. The -15 volt and +15 volt power supplies are scaled with a gain of .1 requiring those values to be multiplied by 10 to get the correct frequency. To get the frequency, it is necessary to divide the value by the time interval since the last logical record. The mirror temperature is fitted to a double exponential curve, and the inverse formula is:

$$\text{Temp} = -124.2 * \ln(\ln(\text{freq})) - 1.765)$$

This value is in degrees Centigrade.

Sample area for the FSSP in square centimeters is 0.00362.

FSSP channel boundaries in microns:

Channel-0 and channel-1 numbers are from Darrel Baumgardner's calibration software (FSPCL.FTN). Numbers for channel-2 and 3 are from the FSSP manual.

Channel 0 2.80, 5.51, 8.57, 11.43, 13.79,
 16.12, 19.58, 23.21, 27.70, 31.83,
 36.36, 40.25, 43.71, 47.14, 50.63, 54.19

Channel 1 2.7, 3.1, 5.0, 8.3, 11.3,
 13.3, 13.6, 15.4, 17.5, 20.7,
 23.6, 25.8, 27.7, 30.1, 34.2, 36.8

Channel 2 1.0, 2.0, 3.0, 4.0, 5.0,
 6.0, 7.0, 8.0, 9.0, 10.0,
 11.0, 13.0, 13.0, 14.0, 15.0, 16.0

Channel 3 0.5, 1.0, 1.5, 2.0, 2.5,
 3.0, 3.5, 4.0, 4.5, 5.0,
 5.5, 6.0, 6.5, 7.0, 7.5, 8.0

PMS One-DC Channel sample areas in square centimeters.

0.00227, 0.01733, 0.05056, 0.09413, 0.13872,
0.18911, 0.24402, 0.28060, 0.26840, 0.25620,
0.24400, 0.23180, 0.21960, 0.20740, 0.19520,
0.18300, 0.17080, 0.15860, 0.14640, 0.13420,
0.12200, 0.10980, 0.09760, 0.08540, 0.07320,
0.06100, 0.04880, 0.03660, 0.02440, 0.01220

PMS One-DC Channel boundaries in microns.

14.2, 34.0, 53.8, 73.6, 93.4,
113.2, 132.8, 152.4, 172.2, 193.6,
211.8, 231.2, 251.0, 270.6, 290.4,
310.0, 330.0, 350.0, 370.0, 390.0,
410.0, 430.0, 450.0, 470.0, 490.0,
510.0, 530.0, 550.0, 570.0, 590.0, 610.0

PMS One-DC Channel mid-points in microns.

24.1, 43.9, 63.7, 83.5, 103.3,
123.0, 142.6, 162.3, 182.9, 202.7,
221.5, 241.1, 260.8, 280.5, 300.2,
320.0, 340.0, 360.0, 380.0, 400.0,
420.0, 440.0, 460.0, 480.0, 500.0,
520.0, 540.0, 560.0, 580.0, 600.0/

PMS One-DP Channel sample areas in square centimeters.

14.85, 16.57, 15.78, 14.99, 14.20,
13.41, 12.62, 11.83, 11.05, 10.26,
9.47, 8.68, 7.89, 7.10, 6.31

PMS One-DP Channel boundaries in microns.

213.0, 510.0, 813.0, 1104.0, 1404.0,
1698.0, 1992.0, 2289.0, 2586.0, 2877.0,
3180.0, 3465.0, 3750.0, 4050.0, 4350.0, 4650.0

PMS One-DP Channel mid-points in microns.

361.5, 661.5, 958.5, 1254.0, 1551.0,
1845.0, 2140.5, 2437.5, 2731.5, 3028.5,
3322.5, 3607.5, 3900.0, 4200.0, 4500.0

The PMS 2D record is 4128 bytes long. Its format is as follows:

PMS 2-D RECORD

4128 BYTES, ARRAY(1032) is a 32 bit integer array.

NAME(SIZE)	TYPE	DESCRIPTION	LOC IN ARRAY
-----	----	-----	---
FRONT(1)	INT	CONSTANT Y'55000000'	0001
IMAGE(1024)	INT	2-D IMAGE SLICES	0002-1025
STTIME(1)	INT	SECONDS FROM MIDNIGHT * 10000 AT START OF 2-D IMAGE	1026
NDTIME(1)	INT	SECONDS FROM MIDNIGHT * 10000 AT END OF 2-D IMAGE	1027
STTAS(1)	INT2	TAS * 100 AT START OF 2-D IMAGE.	1028
NDTAS(1)	INT2	TAS * 100 AT END OF 2-D IMAGE.	1028
SPARE(1)	INT	SPARE LOCATION	1029
DATE(1)	INT	DATE (MMDDYY).	1030
SPRPMS(2)	INT	SPARE LOCATIONS FOR EXPANSION	1031-1032

NOTES :

EACH ELEMENT OF IMAGE REPRESENTS ONE 2-D IMAGE SLICE. EACH BIT OF EACH SLICE INDICATES WHETHER THE CORRESPONDING 2-D PHOTO SENSOR WAS LIT OR UNLIT. A LIT SENSOR INDICATES NO IMAGE AND SETS THE BIT. AN UNLIT SENSOR INDICATES AN IMAGE IS PRESENT AND RESETS THE BIT.

AS WITH THE PMS SLOW RECORD, THE TIME IS ACCURATE TO ONLY THREE PLACES (AFTER DIVIDING BY 10000).

STTIME IS THE TIME WHEN THE 2-D PROBE WAS SIGNALLED TO BEGIN COLLECTING 2-D IMAGES. NDTIME IS THE TIME WHEN THE 2-D PROBE'S BUFFER WAS FULL AND IT SIGNALLED THAT CONDITION.

The diode spacing for this probe is 33 microns.

If you have any questions concerning the format, please contact Martin Brown at:

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University of North Dakota Citation
FIRE Cirrus 2
PMS Probe Data Files

1D Probe - 2048 byte records

<u>Flight #</u>	<u>No. of Records</u>
111491A	5895
112291A	6606
112291B	6614
112591A	8438
112691A	6356
112891A	8710
113091A	4061
120591A	4745
120591B	4423
120791A	5677

2D Probe - 4128 byte records (0 padded to 4608)

<u>Flight #</u>	<u>No. of Records</u>
111491A	1616
112291A	1388
112291B	7433
112591A	2358
112691A	5459
113091A	2485
120591A	5177
120591B	1794
120791A	671

(no file for 11/28 - probe inop)